REMARKS

In section 2 of the Office Action, the Examiner rejected claims 12, 14, and 15 under 35 U.S.C. §103(a) as being unpatentable over the Dobrovolny patent in view of the Milligan patent.

The Dobrovolny patent discloses, in Figure 1, a single-balanced mixer in which a RF signal source 10 is coupled to a ferrite balun 11 that includes a pair of windings 12 and 13 wound on a small toroidal ferrite core (not shown). The balun 11 is in turn coupled to a transformer 14 that includes an input winding 15 and a pair of output windings 16 and 17. Each of the output windings 16 and 17 has one terminal connected to a common junction 18. The other terminals of the windings 16 and 17 are connected to respective drain electrodes of corresponding MESFETs 22 and 26. The source electrodes of the MESFETs 22 and 26 are connected to ground, and the gate electrodes of the MESFETs 22 and 26 are connected to a symmetric local oscillator (LO) source 40 through corresponding capacitors 52 and 53. Resistors 34, 50 and 51 together with capacitors 32, 52 and 53 lower the RF gate-ground impedance of the MESFETs 22 and 26 and develop a negative gate bias voltage for the MESFETs 22 and 26. The junction 18 is connected to a B+ voltage

source through a choke 20 and through a capacitor 24 to an IF output terminal 25 which, together with a grounded terminal 27, comprises the IF output port of the mixer.

A simplified schematic diagram of the mixer is shown in Figure 2. The winding 15 serves as a RF input and induces like-polarity voltages of equal value in the windings 16 and 17. The MESFETS 22 and 26 are represented by corresponding switches 22′ and 26′, and alternately switch the free terminals of the windings 16 and 17 to ground under control of the LO source 40, i.e., at the local oscillator frequency.

Figure 3 shows the effects of this switching. Waveform A represents the RF input signal. Waveform B represents the action of the LO-controlled switches 22′ and 26′. Waveform C represents the resultant output signal available at the IF output terminals 25 and 27 of the mixer. Waveform C includes multiple harmonics, including the desired IF output frequency which may be derived by suitable filtering.

Figure 4 shows a double-balanced mixer. A RF source 50 supplies a balun 51 having windings 52 and 53 coupled to a pair of serially connected RF transformers 54 and 64. The RF transformers 54 and 64 include primary input windings 55 and 65 and pairs of secondary output

windings 56-57 and 66-67, respectively. One end of each of the output windings 56 and 57 of the RF transformer 54 is connected to a terminal 58. One end of each of the output windings 66 and 67 of the RF transformer 64 is connected to a terminal 68. The terminals 58 and 68 are connected to another balun having windings 59 and 69, across which is coupled a choke coil 60. One end of the choke coil 60 is connected to an IF output terminal 72 and the other end of the choke coil 60 is connected to an IF output terminal 71. A source of B+ is connected to the terminal 71, and a bypass capacitor 70 couples the terminal 71 to ground.

The other ends of the output windings 56-57 and 66-67 are coupled respectively to the drain electrodes of respective MESFET pairs 74 and 84. The gate electrodes of corresponding MESFET devices in each pair are connected together, and all of the source electrodes are connected to a DC ground through a common high RF impedance choke coil 75. A first set of gate connections for the MESFET pairs 74 and 84 is connected to one winding 76 of a balun 78, and a second set of gate connections is connected to the other winding 77 of the balun 78. The LO signal is impressed across the balun 78.

An alternate embodiment of the double-balanced mixer of the invention is shown in Figure 5. The embodiment of FIG. 5 is the same as the embodiment shown in FIG. 4, except for the connections associated with the RF transformers 54 and 64. As shown in the Figure 5, the windings 52 and 53 of the balun 51 are connected to the opposite ends of the primary windings 55 and 65, respectively, from the corresponding connections of the Figure 4 embodiment, with the other ends of the primary windings 55 and 65 being connected together at a common ground. Also in contrast to the Figure 4 embodiment, the secondary winding pairs 56,57 and 66,67 are not connected in series, but rather are cross-coupled with each other to form series circuits with the MESFET pairs 74 and 84. Finally, the IF output ports are coupled between the common junctions formed between cross-coupled windings 57, 66 and 56, 67.

The transformers 54 and 64 of Figure 5 may be wound on separate toroidal cores. Alternatively, they may be wound on a common core 90 as shown in Figure 6.

The double-balanced mixers of Figures 4 and 5 operate similarly to the single-balanced mixer of Figure 1 except that even order harmonics are decreased in the IF port terminals 71 and 72. If more than one RF signal

is present, as is common in converters, the resulting inter-modulation is also reduced. Also, LO leakage into the RF port is suppressed.

As the Examiner has recognized, the Dobrovolny patent does not disclose a printed output circuit having a wideband response for receiving a RF signal and being connected to a switching circuit for producing a narrow band IF output signal comprising a frequency difference between a local oscillator signal and a RF signal. Therefore, the Examiner relies on the Milligan patent.

The Milligan patent discloses a broadband mixer comprising two baluns 11 and 12 associated with a RF signal port 13, two baluns 14 and 15 associated with a LO signal port 16, and a balun 17 associated with an IF signal port 18. A frequency converter 19 is coupled between the baluns 11, 12, 14, 15, and 17.

Each of the baluns 11, 12, 13 and 14 is a tapered ground plane microstrip transmission line. The balun 11 has a conductor 31 and a tapered ground plane 34. The conductor 31 is coupled between the RF signal port 13 and a first node 71 of the frequency converter 19, and the tapered ground plane 34 is coupled between ground and a second node 73 of the frequency converter 19.

The balun 12 has a conductor 37 and a tapered ground plane 41. The conductor 37 is coupled between the RF signal port 13 and a third node 72 of the frequency converter 19, and the tapered ground plane 41 is coupled between ground and a fourth node 74 of the frequency converter 19.

The balun 14 has a conductor 45 and a tapered ground plane 48. The conductor 45 is coupled between the LO signal port 16 and the first node 71 of the frequency converter 19, and the tapered ground plane 48 is coupled between ground and the third node 72 of the frequency converter 19.

The balun 15 has a conductor 54 and a tapered ground plane 57. The conductor 54 is coupled between the LO signal port 16 and the second node 73 of the frequency converter 19, and the tapered ground plane 57 is coupled between ground and the fourth node 74 of the frequency converter 19.

The balun 17 is a transformer having windings 61 and 64. The windings 61 and 64 are wound on a core 67 so as to be inductively coupled. The winding 61 is coupled between ground and fifth and sixth nodes 75 and 77 of the frequency converter 19. The winding 64 is

coupled between the IF signal port 18 and seventh and eighth nodes 76 and 78 of the frequency converter 19.

The conductors 31, 37, 45 and 54 are formed as thin metal foils bonded to one side of a dielectric substrate 91, and the tapered ground planes 34, 41, 48 and 57 are formed as corresponding thin metal foils bonded to the opposite side of the dielectric substrate 91 such that the conductor 31 is opposite the tapered ground plane 34 for the balun 11, etc. The baluns common to a signal port, such as baluns 11 and 12, are spaced apart sufficiently on the substrate 91 so they are separate and distinct and there is no interference between them.

Each of the conductors 31, 37, 45 and 54 has a uniform width, and each of the tapered ground planes 34, 41, 48 and 57 is tapered to provide a balanced to unbalanced mode of operation. At the balanced end of the tapered ground planes, the widths of the conductor and the tapered ground plane are the same. The taper in each tapered ground plane minimizes the reflected energy which appears in the even mode at the balanced output and is a high pass structure. For a given length of tapered ground plane, the taper becomes effective above a lower cutoff frequency, and the reflected energy magnitude

ripples with increasing frequency, such that all of the maximum ripple values are equal. Theoretically, this equal rippling has no upper frequency limit, but as a practical matter the upper operating frequency is limited only by the junction capacity of the diodes in the frequency converter 19.

A LO signal is applied to the LO signal port 16, as is usual with a mixer circuit. A RF signal is applied to the RF signal port 13 and is converted to an IF signal at the IF signal port 18.

The Examiner asserts that the Dobrovolny patent is silent with respect to the frequency band of the IF output signal. However, this assertion is not quite accurate. The Dobrovolny patent discloses in column 3, lines 37-40 that the waveform C (i.e., the IF output signal) includes a multiplicity of harmonics which must be suitably filtered in order to provide the desired IF output frequency. Accordingly, the Dobrovolny patent specifically discloses that the IF output signal from the mixer is wide band, not narrow band as required by independent claim 12.

Therefore, even if the Dobrovolny patent and the Milligan patent can be combined, the resulting combination would not result in a mixer that includes a

printed output circuit connected to a switching circuit so as to produce a narrow band IF output signal.

Because a combination of the Dobrovolny patent and the Milligan patent does not result in a mixer that includes a printed output circuit connected to a switching circuit so as to produce a narrow band IF output signal, independent claim 12 is patentable over the Dobrovolny patent in view of the Milligan patent.

Moreover, it is not clear how the Examiner is combining the Dobrovolny patent and the Milligan patent. The Examiner states that the printed circuit board as disclosed in the Milligan patent is being used to implement the mixer circuit disclosed in the Dobrovolny patent. However, the printed circuit board disclosed in the Milligan patent is a complex arrangement incorporating five baluns. It is not apparent or obvious which baluns disclosed in the Dobrovolny patent are being replaced with which foil baluns disclosed in the Milligan patent. The reasons for selecting specific baluns disclosed in the Dobrovolny patent to be replaced with specific foil baluns disclosed in the Milligan patent are likewise not apparent or obvious.

Because of this uncertainty in combining the Dobrovolny patent and the Milligan patent, the Examiner

has not established a prima facie case that independent claim 12 would have been obvious over the Dobrovolny patent in view of the Milligan patent. Therefore, the burden has not shifted to applicants.

For this reason also, independent claim 12 is patentable over the Dobrovolny patent in view of the Milligan patent.

Because independent claim 12 is patentable over the Dobrovolny patent in view of the Milligan patent, dependent claims 14 and 15 are likewise patentable over the Dobrovolny patent in view of the Milligan patent.

<u>In section 3 of the Office Action</u>, the Examiner rejected claim 13 under 35 U.S.C. §103(a) as being unpatentable over the Dobrovolny patent in view of the Milligan patent and further in view of the Freed patent.

<u>The Freed patent</u> discloses, in Figure 1, a balun 100 that includes a balanced input at input terminals 104a and 104b, an unbalanced output at output terminal 106, and a transformer 108 that has an n:1 turns ratio and that converts the balanced input at the input terminals 104a, 104b to the unbalanced output at the output terminal 106. The input terminals 104a and 104b are connected to the output of a mixer 102.

A balun 100′ of Figure 2A includes two discrete capacitors 110a and 110b and an inductor 112. A balun 110′′ of Figure 2B implements the second capacitor 110b as third and fourth capacitors 110c and 110d, which are serially connected to provide an unbalanced output at an output terminal 106′. The balun 100′ of Figure 2A provides balanced-to-unbalanced conversion. The balun 110′′ of Figure 2B provides balanced-to-unbalanced conversion.

A balun 200 shown in Figure 8 includes a balanced input at input terminals 204a and 204b and an unbalanced output at an output terminal 206. The balun 200 also includes an inductor 212, variable capacitors 210a and 210b connected in parallel to the inductor 212, an electronic tuning control port 230 to electronically tune the variable capacitors 210a and 210b, and a decoupling capacitor 222. The output of a mixer 202 is connected to the balanced input terminals 204a and 204b.

As shown in Figure 9, a fixed capacitor 210 is used in place of the variable capacitors 210a and 210b, and an amplifier 234 supplies a DC bias current to the inductor 212 by use of the tuning port 230. Combinations of Figures 8 and 9 may be implemented using a single electronic tuning signal.

Figure 10 illustrates a balun 200'' having four switches 240A, 240A', 240B, and 240B' that switch in and out associated capacitors 242A, 242A', 242B, and 242B'. Fixed capacitors 244A and 244B are also included. The balun 200'' provides four different bands by use of the switches 240A, 240B, 242A', and 242B'.

The variable capacitors 210a and 210b are controlled by an electronic tuning signal 232 for fine tuning. The switched capacitors 242A, 242B, 242A', and 242B' provide for coarse tuning as controlled by electronic tuning signals at ports 246a and 246b.

A balun 200 of Figure 11 may be used in connection with a pair of local oscillators LO1 and LO2 and a switch 252. Two RF frequencies RF1 and RF2 may be used with the mixer 202 and the electronic tuning signal at the port 232.

Figure 12 of the Freed patent illustrates baluns combined with a mixer having a synthesized local oscillator under common microprocessor control.

<u>Dependent claim 13</u> recites that the output circuit includes parallel tuned elements exhibiting the wideband response and series tuned elements exhibiting the narrow band response.

The Examiner correctly recognizes that neither the Dobrovolny patent nor the Milligan patent discloses an output circuit having parallel tuned elements such that a wideband response for receiving a RF signal is exhibited and series tuned elements such that a narrow band IF output signal is produced. Therefore, the Examiner relies on the Freed patent.

According to the Examiner, the Freed patent discloses an adjustable balun having either parallel tuned elements as shown in Figure 9 or series tuned elements as shown in Figure 8 to change the frequency of an output signal.

However, the baluns of both Figure 8 and Figure 9 rely on parallel tuned elements. As can be seen, the tuned elements in Figure 8 comprise two variable capacitors 210a and 210b connected in parallel to the inductor 212, and the tuned elements in Figure 9 comprise a single fixed capacitor 210 connected in parallel to the inductor 212.

Accordingly, a premise of the Examiner's rejection is incorrect and the rejection, therefore, must fail. Consequently, dependent claim 13 is patentable over the Dobrovolny patent in view of the Milligan patent and further in view of the Freed patent.

Moreover, the Examiner asserts that it would have been obvious to use parallel tuned elements so that a wideband RF response is exhibited and to use series tuned elements so that a narrow band RF response is exhibited because the mixer disclosed in the Dobrovolny patent is intended to have a wideband RF response.

There are at least two problems with this assertion. First, none of the references relied on by the Examiner suggests an output circuit having a narrow band RF response. Indeed, as discussed above, the Dobrovolny patent actually discloses a mixer with an output circuit that has a wideband IF response. Moreover, the Milligan patent and the Freed patent are silent on whether the mixer output circuit should have a narrow band IF response.

Accordingly, none of the references cited by the Examiner in the rejection of dependent claim 13 suggests an output circuit that provides a narrow band IF response. Therefore, for this reason, dependent claim 13 is patentable over the Dobrovolny patent in view of the Milligan patent and further in view of the Freed patent.

Second, the Dobrovolny patent does not disclose the use of parallel tuned elements so that the output circuit exhibits the wideband RF response. Indeed, the

Dobrovolny patent discloses that wideband response is obtained without the use of parallel tuned elements.

Accordingly, the Dobrovolny patent teaches away from the use of parallel tuned elements to achieve a wideband response. Therefore, for this reason also, dependent claim 13 is patentable over the Dobrovolny patent in view of the Milligan patent and further in view of the Freed patent.

CONCLUSION

In view of the above, it is clear that the claims of the present application are patentable over the art applied by the Examiner. Accordingly, allowance of these claims and issuance of the above captioned patent application are respectfully requested.

Respectfully submitted,

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